

Estimating the Risks in Defined Benefit Pension Funds  
under the Constraints of PF117

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## PLAGIARISM DECLARATION

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## ABSTRACT

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With the issuing of Pension Funds circular PF117 in 2004 in South Africa, regulation required valuation assumptions for defined benefit pension funds to be on a best-estimate basis. Allowance for prudence was to be made through explicit contingency reserves, in order to increase reporting transparency. These reserves for prudence, however, were not permitted to put the fund into deficit (the no-deficit clause). Analysis is conducted to understand the risk that PF117 poses to pension fund sponsors and members under two key measures: contribution rate risk and solvency risk. A stochastic model of a typical South African defined benefit fund is constructed with simulations run to determine the impact of the PF117 requirements. Findings show that a best-estimate funding basis, coupled with the no-deficit clause, results in significant risk under both contribution rate and solvency risk measures, particularly in the short-term. To mitigate these risks, alternative ways of introducing conservatism into the funding basis are required, with possible options including incorporating margins into investment return assumptions or the removal of the no-deficit clause.

Keywords: best-estimate assumptions, stochastic simulation, pension fund

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# 1 INTRODUCTION

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With the issuing of Pension Funds circular PF117 in 2004, regulations required valuation assumptions for surplus apportionment for defined benefit (DB) pension funds to be on a best-estimate basis. To account for a probable weakening of the valuation basis, allowance for prudence was to be made through explicit reserves. However, these reserves for prudence were not permitted to be so large as to put the fund into deficit (the so-called no-deficit clause). Effectively, this decoupled the reserving basis from the funding basis.

The introduction of PF117 represented a new way of approaching pension fund valuations which had not been tested in practice over extended periods, especially the introduction of the no-deficit clause. In particular, the approach could result in an increased probability that assets would be insufficient to meet future benefits. For example, where an actuary wished to set up prudent reserves that would put the fund into deficit, they were prevented from doing so by the no-deficit clause. The deficit would require increased employers' contributions to restore financial soundness; in such cases, PF117 could have the effect of perpetuating an unsound condition.

While PF117 is explicitly directed at the method and assumptions used to determine surplus at the surplus apportionment date, the circular does provide that a minimum best-estimate valuation basis for funding is also acceptable. This raises the concern that sponsors would prefer to pay contributions on the best-estimate basis, creating risk for the security of members' benefits.

Davis and Kendal (2012) suggested that further research should be done to determine whether the new approach is more risky for members. This dissertation is in response to the call for further research. This research explores the impact of Pension Funds circular PF117 on the security of members' benefits by defining and measuring key risk criteria under a number of different scenarios (using a stochastic investment model). The research aims to quantify the additional risk, if any, PF117 poses to members, specifically identifying the impact of the no-deficit clause.

## 1.1 Research question

The introduction of PF117 brought with it a shift from (prior to PF117) the use of a valuation basis with prudence implicit in some or all of the assumptions to a basis (post PF117) where each assumption was a best estimate and where prudence could be

introduced explicitly by use of various contingency or solvency reserves. This represented a new way of approaching pension fund valuations which had not been tested in practice over extended periods, especially the introduction of the no-deficit clause.

Davis and Kendal (2012) questioned the rationale for this new approach and suggested that further research should be done to determine whether the new approach is more risky for members. Specifically, Davis and Kendal (2012:122) state: “Some of the methodologies of PF117 are called into question. In particular, the no-deficit clause seems to have no actuarial justification at all, but leads to a number of problems. In the first place it decouples the funding basis from the reserving basis. At one end of the spectrum, one can have a scheme both funded and reserved for on a best-estimate basis. In such a case there is a 50% risk that assets will be insufficient for accrued benefits and a 50% risk that the contribution rate will be insufficient to fund for future benefits. Before this is adopted as an acceptable method, it is essential that research be done, perhaps using stochastic modelling, to determine the levels of risk inherent in this approach.”

The overall purpose of this research is to answer the question: Do the constraints of PF117 introduce additional risk to the security of members’ pension benefits? This research will analyse the security of members’ benefits, the extent to which and how often it is placed at risk under the guidelines of PF117. The specific sub-questions include:

1. What is meant by risk in this new valuation approach?
2. What metrics can be used to measure that risk?
3. What is the effect of moving to a best-estimate basis?
4. What are the implications of the no-deficit clause?

## **1.2 Chapter outline**

The research begins with a discussion of the relevant legislation and regulation guiding the valuation of pension funds in South Africa, shown in chapter 2. In addition, Chapter 2 presents a review of literature covering the use of best-estimate valuation bases, stochastic modelling techniques for investment returns, methods for forecasting pension fund risks, and funding methods for defined benefit pension funds. Chapter 3 outlines the methodology for constructing the synthetic pension fund, simulating stochastic investment returns and the valuation basis to be used. The results of the analysis are shown in Chapter 4, including sensitivities to key assumptions and different strategies for managing the risk. Chapter 5 synthesises the results, reflects on the research question above, and discusses avenues for further research.

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## 2 BACKGROUND AND LITERATURE REVIEW

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This chapter first provides background on the relevant legislation and regulation guiding the valuation of pension funds in South Africa. Thereafter, a more detailed review of literature on the topic is presented. Given the peculiar nature of the no-deficit clause, there is little published literature on a valuation approach exactly as described in PF117 (e.g., the introduction of a no-deficit clause). The literature reviewed therefore covers the use of best-estimate valuation bases, stochastic modelling techniques for investment returns, methods for forecasting pension fund risks, and funding methods for defined benefit pension funds.

### 2.1 Background

The valuation of pension funds in South Africa, and the determination of actuarial surplus, has been guided by the release of the Pension Funds Second Amendment Act (No. 39 of 2001), Regulation 35 (Pension Funds Amendment Regulations, 2003), the Pension Fund Circular PF117 (FSB, 2004), and PF Notice No. 2 of 2016 (FSB, 2016).

The Pension Funds Second Amendment Act (PFSAA) was enacted to make new provisions for the apportionment of actuarial surpluses and for minimum benefits by amending the Pension Funds Act of 1956. It aimed to address two historical issues. First, members who left a fund before retirement having not received their full actuarial reserve and whose pension increases have not increased with inflation. Second, the ownership of any actuarial surplus arising in a fund needed resolution; specifically, whether this belonged to the sponsor or members (Pension Funds Second Amendment Act, No. 39 of 2001). As cited by Davis and Kendal (2012), prior to the release of the PFSAA, there were conflicting views between labour and business on the ownership of actuarial surplus. Labour's view was that "actuarial surplus belonged to the retirement fund and should be used for the benefit of members of that fund unless it could be shown to have resulted from deliberate over-contribution by the employer" (Davis and Kendal, 2012:100). Business's view was that "any actuarial surplus had arisen because of overly conservative assumptions relative to the experience of the fund; and therefore had resulted, in effect, from the payment by the employer of more contributions than had actually been required" (Davis and Kendal, 2012:100).

The PFSAA defines actuarial surplus for defined benefit funds as the difference between:

1. the actuarial value of assets less member and employer surplus accounts; and
2. the actuarial value of accrued liabilities plus contingency reserve accounts

(which may be established by the board of a fund on the advice of the valuator to provide for explicit contingencies).

The member and employer surplus accounts hold as credit any surplus apportionment allocated by the board to the members and employer respectively under the guidance of the PFSA, as well as the associated investment returns. Once actuarial surplus is apportioned to either the member or employer surplus accounts, members and the employer acquire rights to the actuarial surplus in the respective accounts for utilisation (e.g., benefit improvement for members). Under the PFSA, prudence in the valuation of a fund could be introduced through margins in the valuation assumptions as well as through explicit contingency reserves.

In April 2003, the Minister of Finance issued regulation 35 to the PFSA. With its issuance, the Minister encouraged greater scrutiny of existing margins for prudence in pension funds because any excessive margins would reduce surplus available and the likelihood of benefit restitution. In particular, regulation 35 aimed to ensure that any contingency reserve established by a fund is not done in bad faith in order to deny former members access to the surplus. Specifically, regulation 35 states (Pension Funds Amendment Regulations, 2003:5):

“(1) By virtue of the fact that:

(a) the Act vests powers in boards of funds to establish contingency reserve accounts; and

(b) the establishment of contingency reserve accounts reduces the actuarial surplus available for apportionment and increases the possibility that actuarial surplus may be insufficient to enhance benefits previously paid to former members to the level prescribed in section 156 (5) (b) of the Act,

no fund may, with effect from the date of commencement of this regulation, establish any contingency reserve account under circumstances where a reasonable inference may be made that the establishment of the account is contrary to the duties of the relevant board under section 7C (2) (b) of the Act and motivated by bad faith.

(2) The establishment and magnitude of any contingency reserve account by a fund:

(a) must be motivated by the valuator in the relevant report on the statutory actuarial valuation; and

(b) may, where the Registrar is not satisfied with any such motivation, be rejected by the Registrar.”

In July 2004, the Financial Services Board (FSB) issued Pension Fund Circular PF117. The FSB is an independent body monitoring and regulating the non-banking financial sector of South Africa. It is given power through statute, and aims to promote and maintain a sound financial investment environment in South Africa (FSB, 2015). The circular’s aim was to set out the standard for pension fund valuations, ultimately affecting the actuarial surplus identified at the surplus apportionment date (FSB, 2004).

The need for the circular’s issuance was largely due to regulation 35. In many valuations, the degree of prudence in a basis was not always clear because implicit margins were incorporated into the various assumptions. Because of the requirements and implications of regulation 35, this lack of transparency was now less acceptable. While regulation 35 focused on the establishment of contingency reserves, it did not include specific requirements around the margins used in the valuation assumptions. PF117 sought to address this by requiring assumptions to be on a best-estimate basis (i.e., no margin for prudence), with prudence being allowed for through explicit contingency reserves. While PF117 is explicitly directed at the method and assumptions used to determine surplus at the surplus apportionment date, the circular does provide that a minimum best-estimate valuation basis for funding is also acceptable. This raises the concern that sponsors would prefer to pay contributions on the best-estimate basis, creating risk for the security of members’ benefits. Beyond this however, PF117 did not seem to place any constraints on how contributions were to be determined beyond the surplus apportionment date. Further, while circulars issued by the FSB are not law, the circulars aim to reflect what the Registrar would normally find acceptable.

There is some question about what exactly “best-estimate assumptions” are. PF117 defines a “best-estimate assumption” as an assumption that (FSB, 2004:2):

1. “is realistic;
2. depends on the nature of the business concerned; and
3. is guided by past experience, as modified by any knowledge or expectation of the future, including events, such as changes in tax legislation, which impact the expected experience of the fund.”

PF117 (FSB, 2004:2) further states that “no deliberate margins for conservatism should be included in the assumptions” and explains that “the assumptions should be motivated by reference to any of the following:

1. the experience of the fund, taking into account the size of the fund and underlying trends in that experience where the actuary deems it appropriate to do so;
2. statistical evidence relating to
  - 2.1. funds in general, or
  - 2.2. relevant published annuitant or in-service mortality or morbidity, including the effect of HIV/AIDS, or
  - 2.3. an investigation performed within a firm of valuers in respect of funds advised by that firm where that evidence may relate to demographic items or to economic items such as the equity premium; or
3. yields on classes of government or corporate bonds which, in terms of the actuarial method used by the valuator, determine the discount or inflation rates assumed at the valuation date.”

As pointed out by Davis and Kendal (2012), the definition of a best-estimate basis used by the Actuarial Society of South Africa (ASSA) would result in a 50 per cent chance of being underfunded. By either definition, in the absence of contingency reserves, the use of best-estimate assumptions may result in an increased probability of assets being insufficient to meet liabilities than has been past practice in South Africa.

Following the use of best-estimate assumptions, PF117 allows for the establishment of explicit contingency reserves for prudence. However, the board may establish these contingency reserves accounts provided “the need for such account is fully justified and the establishment of the contingency reserve account does not result in a deficit” (referred to as the no-deficit clause) (FSB, 2004:4).

The use of these contingency reserves for prudence would effectively allow for greater transparency in the degree of prudence adopted, as required by regulation 35. However, by preventing the reserve from putting the fund into deficit, the peculiar nature of the no-deficit clause has a number of implications. Davis and Kendal (2012) find the no-deficit clause to be actuarially unjustifiable for a number of reasons. First, the no-deficit clause implies that a contingency reserve is important enough to deny a former member restitution but not important enough to require increased contributions from the sponsor. Second, the no-deficit clause decouples the reserving basis from the funding basis. Funding would be on a best-estimate basis, while reserving would depend on the extent of contingency reserve used. In some cases, the reserving would be the same as the best-estimate basis (where the no-deficit clause prevented the establishment of a

contingency reserve). Third, actuaries would not be able to increase sponsors' contributions in cases through reserves where these reserves would put the fund into deficit. Arguably, this could lead to the persistence of poor financial conditions in funds. For example, a fund in deficit would require increased contributions from the sponsor. Under PF117 actuaries would be unable to impose any reserves under the no-deficit clause.

Davis and Kendal (2012) conducted an analysis of the valuation bases of 447 pension funds before and after the issuance of PF117. Based on the requirement to remove implicit margins from the valuation basis, one would expect the valuation bases to be weaker post PF117. For 118 of the funds, this appeared to be the case: the valuation basis was weakened and an associated contingency reserve was set up to bring the prudence up to a level similar to that in the previous valuation basis (Davis and Kendal, 2012). However, for 222 of the funds (which was the majority), valuation bases were explicitly strengthened (Davis and Kendal, 2012). For many of these funds, explicit contingency reserves were also set up. The result for these 222 funds is not as expected, implying that actuaries (post PF117) considered the previous valuation bases (which at the time should have been considered to be sufficiently prudent) to be weaker than the best estimate (Davis and Kendal, 2012). Overall, the results suggest that PF117 may not have had the desired effect and may in fact have increased the difficulty around establishing the degree of prudence applied.

In July 2016, the FSB published PF Notice No. 2 of 2016 (FSB, 2016). The notice sets out the criteria for financial soundness and the valuation basis with which financial soundness is determined (FSB, 2016). As in PF117, the notice sets out similar guidelines for the determination of actuarial assumptions. While the notice does not refer to the no-deficit clause as in PF117, it provides that the minimum acceptable basis for funding is the best-estimate basis, and that surplus can only be recognised to the extent that assets exceed liabilities calculated on a prudent basis (bond-based or funding, whichever results in a larger liability valuation). Trustees, however, are only to support a best-estimate basis in the case where the sponsor has the means to cover future injections that might be required.

## **2.2 Realistic valuation bases**

Thornton and Wilson (1992) investigated the use of realistic bases in funding pension funds, given that typical bases contained significant margins. Operating in the U.K. at a time where legislation was quickly evolving to encourage greater transparency of



assumptions, Thornton and Wilson (1992) mention a number of reasons for using a realistic basis in funding. First, where members had the option to opt-out of occupational schemes and take a personal pension, any comparison of projected benefits with a final salary scheme needed to be as objective as possible. Second, when occupational schemes started including money purchase underpins (or minimum benefits), realistic assumptions were needed to set the appropriate level of underpin and accurately determine the costs. Third, when members transferred between schemes, conservative bases led to excessive assets being transferred and too low a price being paid (Thornton and Wilson, 1992).

Thornton and Wilson (1992) suggest that typical valuation bases contain significant margins for prudence, and demonstrate the dangers of these margins in the long term using a model fund. Their conclusion is that while some degree of prudence is appropriate for funding purposes, overly conservative margins for prudence should be avoided as they could result in a significant build-up of surplus should it not be managed correctly through amortisation. Their analysis of assumptions used showed that the average basis may include margins that lead to an overestimation of benefits of approximately 10 per cent. They also comment that where margins do need to be included, these should be in the investment return assumption, given the sensitivity and importance of this assumption.

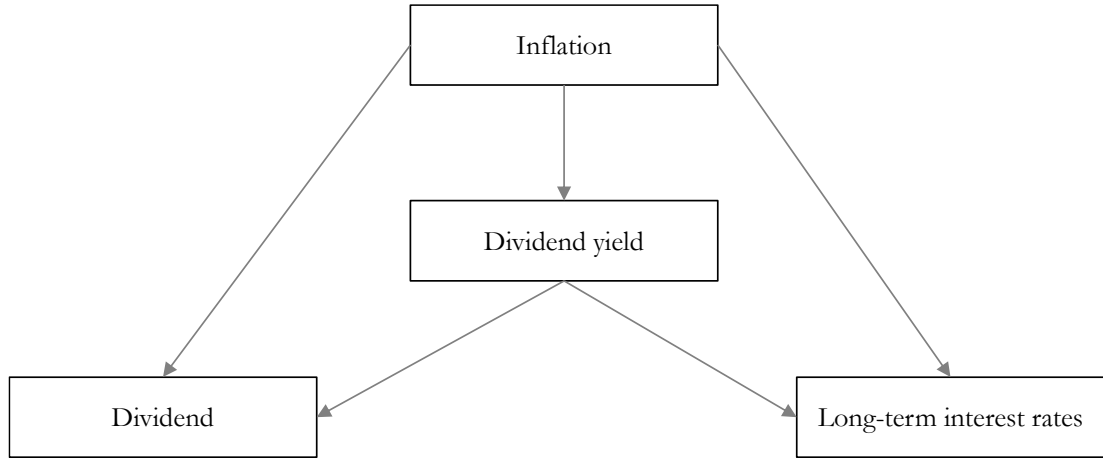
In their analysis, Thornton and Wilson (1992) consider what exactly defines a realistic assumption. They make a distinction between a realistic assumption and a best-estimate assumption, explaining that the latter is the natural starting point for developing the former. They support the definition outlined in Chapter 1 that the best estimate for a parameter value is a value that is equally likely to be too large or too small. They suggest that the starting point for defining the best-estimate assumptions is the consideration of past history, specific to the fund and for an appropriate time horizon, which also aligns with the guidance provided in PF117. They, however, suggest that to move to a realistic basis, which may be more appropriate for funding, the actuary may choose to introduce margins for caution in the assumptions (e.g., to make allowance for future uncertainty). It is clear from the definition of best-estimate used in PF117 that it resembles a best-estimate basis rather than a realistic basis, as described by Thornton and Wilson (1992).

## **2.3 Modelling techniques**

Critical to the research is developing a set of stochastic investment returns for simulating the pension fund performance. One of the earliest stochastic investment models for actuarial use is the work of Wilkie model (1984), developed in the context of the U.K. The model focuses on long-term projections in annual time steps, which as explained by

Wilkie (1984), would typically be the need of an actuary. The hypothesis is that inflation is the driver of other key investment variables, including long-term interest rates, dividends, and dividend yields. These variables are not assumed to affect each of the others, but rather a cascading structure is adopted as shown in Figure 2.1 below. These variables are modelled using autoregressive processes of various orders (e.g., a first order autoregressive process is used to model inflation).

**Figure 2.1: Cascading structure of the Wilkie (1984) model**



Publications on stochastic investment models for the South African context are limited. Probably the best known is that proposed by Thomson (1996), which was the first published and fully descriptive model for actuarial use in South Africa. He found that the Wilkie (1984) model was not suitable for South African data, and that a different model structure was required (particularly for medium-term projections). Thomson (1996) describes a methodology for developing time-series models for key economic variables including inflation, interest rates, dividends and rental yields. He uses an autoregressive integrated moving average (ARIMA) process to model inflation, with equity dividend growth as the input. He outlines the general approach, as shown below (Thomson, 1996:766):

$$Y_t = \sum_{j=1}^J \frac{\omega_{j,0} - \sum_{i=1}^{S_j} \omega_{i,j} B^i}{1 - \sum_{i=1}^{r_j} \delta_{i,j} B^i} X_{j,t} + \frac{1 - \sum_{i=1}^q \theta_i B^i}{1 - \sum_{i=1}^p \phi_i B^i} \eta_t \quad \text{Equation 2.1}$$

where  $Y_t$  is the value of the variable being modelled (i.e., the output variable),  $X_j$  is the value of the  $j$ th input variable at time  $t$ ,  $\eta_t$  is a white-noise variable, and  $B$  is the backwards operator with respect to time (i.e.,  $B^i X_{j,t} = X_{j,t-i}$ ).

The model represents an extension of the well-known Wilkie model (1984) adapted to the South African context and data. Whereas the Wilkie (1984) model was intended for long-term projections, the model produced by Thomson (1996) was intended to be used for projections not further than 10 years. This was because the model was based on only 34 years' worth of South African data. The model uses annual time periods, as was done by Wilkie (1984).

Other linear models include Sherris, Tedesco and Zehnworth (1999) and Claassen (1993), who outlined the structure of a model for the South African context, but did not provide statistical evidence of its applicability or performance.

Later models used non-linear approaches through autoregressive conditional heteroscedastic (ARCH) models, which were introduced by Engle (1982). As cited by Maitland (2010), these models include the inflation model of Wilkie (1995) and Hua (1994). Markov switching models represent another form of non-linear models, and were first introduced by Goldfield and Quandt (1973). They were emphasised by the work of Hamilton (1989, 1990), who describes the likelihood function and an efficient estimation technique for fitting such models.

Maitland (2010) identified a number of statistical problems and estimation errors with the models proposed by both Thomson (1996) and Wilkie (1984). For example, mean reversion in certain variables created risk-adjusted returns that violated the Efficient Market Hypothesis (EMH). The models also suffered from parameter instability and bias, making them unsuitable for long-term projections (Maitland, 2010).

To overcome the shortcomings of previous approaches, Maitland (2010) constructed a Multiple Markov Switching (MMS) model of South African financial and economic variables. Maitland (2010) starts by conducting a detailed review of the Thomson (1996) model, and thereafter develops a MMS model to improve the asset and liability modelling process. This model represents a new class of Markov switching models where switches in variables are not perfectly correlated. The variables modelled include the inflation rate, the 0-year nominal yield, the 20-year nominal par yield, and the total return on equities. This differed from the approach of Thomson (1996), where the equity dividend yield and dividend growth rates were modelled, as opposed to the total return on equities. The model uses quarterly time intervals as opposed to annual time intervals (used by Thomson (1996) and Wilkie (1984)), as quarterly time intervals allow for a wider range of applications (e.g., comparison with investment performance results, which are often reviewed quarterly). While the model provides a reasonable description of South

African data and is suitable for long-term projections, it is a more complex approach to forecasting that is not easily replicable.

Blake, Cairns and Dowd (2001) provide an account of a variety of modelling approaches particularly in the context of pension funds. The models considered include stationary moments (e.g., multivariate normal model), regime-switching (e.g., Markov switching model) and fundamental models (e.g., Wilkie (1995)). These models are used in order to determine the estimated value-at-risk (VaR) in the accumulation phase of a defined-contribution (DC) pension fund. They conduct a stochastic simulation to forecast the future value of a pension fund, given that a stochastic approach provides a distribution of outcomes. The key variables they model include asset returns (on equities, bonds, and money market instruments), interest rates, and salary growth. They find that the VaR is sensitive to the asset-return model used and its parameterisation, but to a lesser extent than the chosen asset-allocation strategy.

Although not specific to the South African context, Blake, Cairns and Dowd (2001) provide an excellent account of the modelling approaches which can be developed for the South African context using the appropriate historical asset class data for parameter estimation. In particular, they outline a number of stationary moments models: a class of models which assumes the unconditional first and second moments of asset returns are independent from one year to the next (Blake, Cairns and Dowd, 2001). They outline a simple approach to developing a multivariate normal model for a number of correlated asset classes using a Cholesky decomposition (Blake, Cairns and Dowd, 2001:208).

Specifically: Let  $L=[l_{ij}]$  be the lower-triangular Cholesky decomposition of the correlation matrix,  $C$ , such that  $l_{ij}=0$  for all  $j>i$ , and  $C=LL'$ . Let  $\mu_i$  be the mean return on asset  $i$  and  $\sigma_i$  be the standard deviation of the return on asset  $i$ . Additionally, let  $r_i$  be the annual return of the specific asset class in year,  $\zeta_i$  represent independent standard normal variables (i.i.d.  $\sim N(0,1)$ ) and  $Z_i$  represent correlated standard normal random variables. Then:

$$Z_i = \sum_{j=1}^n l_{ij} \zeta_j \quad \text{Equation 2.2}$$

$$r_i = \mu_i + \sigma_i Z_i \quad \text{Equation 2.3}$$

The result is a series of correlated asset returns for each asset class modelled.

## 2.4 Forecasting pension fund risks

An important question needing to be answered is what is defined as risk in the context of this research. Following the approach of Haberman (1993), Haberman and Sung (1994), Haberman (1997), and Josa-Fombellida and Rincon-Zapatero (2001), two key risks identified are contribution rate risk and solvency risk.

Contribution rate risk is defined as the risk that the sponsor is unable to meet the required contributions to the fund. As described by Haberman (1997:1): “Here the sponsor of the scheme will be concerned that future investment performance is not such as to expose the pension fund to the risk of significant changes in the contribution rate. Stability will also be a feature attractive to the finance manager and the shareholders of the employing/sponsoring company.” Solvency risk is defined as the ability of the fund to meet its liabilities as they fall due or should it be wound up. These two risks are not independent, with Haberman (1997:2) explaining: “The actuary will set the level of contribution to attempt to achieve both the stability of the contributions and the security of the pension fund in an attempt to weigh the conflicting interests of the sponsoring employer and the trustees/members with regard to the long term financial health of the scheme.”

The work of Haberman (1997) is of particular relevance to this research. He focuses specifically on contribution rate risk, and investigates the impact of different funding methods and different periods of spreading surpluses or deficits on minimising contribution rate risk. A mathematical model is constructed to represent the financial structure of a defined benefit pension scheme, in particular the relationship between the contribution rate and the fund level at a particular time. The aim of Haberman (1997) was to minimise the variability in the present value of future contributions: representing contribution rate risk. His conclusion is that there is an optimal value for the choice of period for distributing surplus or deficit that minimises contribution rate risk, but this value varies with the assumed standard deviation of the valuation interest rate. For example, for low standard deviations, the optimal period is as large as possible (i.e., to postpone the corrections to the contribution rate for as long as possible).

Specifically, Haberman describes the model developed for the pension fund as follows (1997:128):

Let  $C(t)$  and  $F(t)$  be the overall contribution rate and funding level respectively at time  $t$ . Let  $NC(t)$  be the total normal cost at time  $t$  and  $AL(t)$  be the total actuarial liability at time  $t$ , in respect of all members (i.e., those active and those retired).

Then

$$C(t) = NC(t) + ADJ(t), \quad \text{Equation 2.4}$$

where

$$ADJ(t) = \frac{UL(t)}{\ddot{a}_M} \quad \text{Equation 2.5}$$

and

$$UL(t) = AL(t) - F(t). \quad \text{Equation 2.6}$$

Here,  $UL(t)$  is the unfunded liability at time  $t$  and  $ADJ(t)$  is an adjustment to the contribution rate at time  $t$  based on the prevailing unfunded liability. In the case Haberman (1997) considers,  $ADJ(t)$  is taken to be equal to the overall unfunded liability divided by the present value of an annuity for a term of  $M$  years – referred to as the “spread” method of contributions with either surpluses or deficits.

The behaviour of  $C(t)$  is then considered under the presence of stochastic investment returns. However, to ensure that no noise is introduced into the contribution rate (e.g., the effect of an ageing membership or change in the membership distribution), Haberman introduces a number of key assumptions. First, he assumes that all actuarial assumptions are consistently borne out by experience, except for investment returns. Second, the population is assumed to be stationary from the start (i.e., the age, sex, and salary distribution of the population remains constant from each year). This assumption in particular is critical to ensuring accurate conclusions on the variability of the contribution rate can be drawn. Third, there is no salary inflation (including promotional salary increases). Fourth, the valuation interest rate is fixed. These four assumptions then imply that  $NC(t)$ ,  $AL(t)$  are constant with respect to time,  $t$ . To then analyse the behaviour of the contribution rate  $C(t)$ , Haberman (1997) defines the present value of future contributions at time  $0$  to time  $t$  as  $G(t)$ , and investigates the first and second moments thereof.

Other papers have also proposed similar approaches to measuring pension fund risks. Josa-Fombellida and Rincón-Zapatero (2004) follow a similar approach to Haberman (1997). They assume that the aim of the sponsor is to minimise a combination

of contribution rate risk and solvency risk, and analyse this under both deterministic and stochastic liability scenarios. They develop a complex function to simultaneously minimise both types of risk. The focus on contribution rate risk and solvency risk is also followed by Haberman (1993), Haberman and Sung (1994), Haberman (1997), and Josa-Fombellida and Rincón-Zapatero (2001). Arnott, Bernstein, and Hall (1991) discuss the move to focus on the variability of pension fund surplus (which relates to solvency risk) as the key measure of risk in defined benefit pension funds.

## **2.5 Funding methods**

Important to developing the model of the pension fund is selecting an appropriate funding method. Haberman (1997) does not make specific distinctions between the different funding methods, using a simplified approach to determine the modified contribution rate. However, in developing their modelling approach, Thornton and Wilson (1992) consider what the most appropriate funding method would be. They consider the Current Unit and Projected Unit methods (accrued benefit methods) and the Attained Age and Entry Age methods (prospective methods). They favour the use of the Projected Unit method for three reasons. First, the distinction between the level of funding for accrued benefits and the ongoing contribution required for future accruing benefits is made clear. Second, the funding requirements are consistent with the assumption that the pension scheme is a going concern. Third, the funding requirements are based on the estimated future cost of the benefit promises made (Thornton and Wilson, 1992).

The use of accrued benefit methods are also supported by Marshall and Reeve (1993), who built on the work of Thornton and Wilson (1992). They consider the funding methods under the criteria of stability, liquidity, security, and sufficiency. They find that prospective methods fail to address the requirement of sufficiency, which could result in excessive resources being allocated to the fund and hence generating surpluses.

## **2.6 Summary of the approach in this paper**

Based on the review above, this research uses a multivariate normal model as described by Blake, Cairns and Dowd (2001) to stochastically simulate investment returns. Risk is considered by measuring both contribution rate risk and solvency risk, as outlined by Haberman (1997). The contribution rate, and hence funding of the pension fund, is determined using the Projected Unit funding method, as supported by Marshall and Reeve (1993).

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### 3 METHODOLOGY AND DATA

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This chapter describes the approach to constructing the stochastic model and the estimation of contribution rate risk and solvency risk. In addition, this chapter outlines the economic and demographic assumptions used for the simulation.

#### 3.1 Overview

A model of a synthetic defined benefit pension fund is developed to assess the contribution rate and overall funding level under different scenarios. The fund constitutes a number of members, both active members and pensioners. To capture the required level of variability, key economic assumptions are modelled stochastically, including investment returns and inflation. A number of simulations are run to determine the average and volatility of the contribution rate and funding level under different scenarios.

As defined in section 3.3, the key measurement criteria are the contribution rate and funding level throughout the period. The contribution rate gives an indication of the sustainability of the contributions and whether the sponsor can meet the contribution requirement. The funding level provides a measure of the overall security of members' benefits, with high funding levels suggesting sufficient assets to cover liabilities. The funding level also, particularly under a best-estimate valuation basis, shows the risk of underfunding and the occurrence thereof. These measures are compared against the thresholds defined in section 3.3 to determine the appropriate risk classification (high, medium or low).

A number of simulations are conducted to determine the proportion of outcomes with low, medium, and high risk. A key focus is the proportion of these simulations that are either classified as medium or high risk. These risk classifications are then also examined under different strategies to mitigate the risk. These strategies include differing terms for dealing with deficits/surpluses, applying or not applying the 'no-deficit' clause, and using differing levels of contingency reserves. A sensitivity analysis of the results to changes in key variables is also conducted to understand the robustness of the results and the implications on the conclusions drawn.

An additional measurement criterion of interest is the frequency of the need to implement the no-deficit clause. In particular, it would be important to observe the frequency with which the no-deficit clause prevents prudent reserves being set up.



Further, the no-deficit clause may result in the high occurrence of a 100 per cent funding ratio in the fund.

As far as possible, parameters are estimated from data from the retirement industry. Discretion is applied to ensure these parameters are aligned with industry standards, and where data are scarce. By using the same basis for the deterministic three-yearly valuations, and the underlying basis behind the stochastic approach to modelling the actual fund assets, a best-estimate basis is effectively being used in the model for the simulations. For the purpose of the analysis, it is less important that the basis should be entirely realistic in the sense that each parameter reflects the real world. Nevertheless, the valuation basis is anchored in the real world by making use of what valuers assumed to be best-estimate assumptions when they were operating under the constraints of PF117. The extent to which this rationale can be criticised would lessen our confidence in the results obtained.

### **3.2 Projection process**

In South Africa, valuations have almost invariably been done on a deterministic basis to arrive at an asset to liability ratio and contribution rate at the valuation date; which is the approach used in this research to value the liabilities. A triennial valuation period, which is the statutory maximum, is used; equating to a triennial control period. The model projects over eight such periods. In each valuation year, the liabilities and theoretical contribution rate are calculated deterministically on the long-term best-estimate basis. A stable membership profile is assumed: in other words as members exit the fund, a new member with exactly the characteristics required to maintain the age, gender, and salary distribution in the fund is assumed to join at the point of exit. Macroeconomic variables are varied stochastically to represent actual experience of the fund and determine the resulting fund assets. The interaction of these deterministic and stochastic components gives rise to the two metrics (contribution rate and funding ratio), which are being used as a proxy to measure risk. Within this projection framework, the model allows one to insert different strategies (including the no-deficit clause) for dealing with surplus/deficit. The base strategy assumed is that all deficits are to be eliminated within three years, as per statutory requirement in South Africa.

### **3.3 Measuring risk**

The two key risks that are investigated are the contribution rate risk and solvency risk, following the approach of Haberman (1993), Haberman and Sung (1994), Haberman (1997), and Josa-Fombellida and Rincon-Zapatero (2001). The contribution rate risk is

defined as the risk that the sponsor is unable to meet the required contributions to the fund. Based on the actual experience of the fund, the contribution rate would naturally vary from one valuation to the next. The extent of this variation will depend on how far the actual experience differs from that assumed in the valuation basis. By using a best-estimate valuation basis, the risk arises that the contribution rate could fluctuate significantly at each valuation, potentially beyond the affordability of the sponsor. The level that is affordable by the sponsor is, however, dependent on the size of the sponsor's profit margin relative to the salary roll, which may differ by type of business.

Nevertheless, to evaluate the extent of the risk, a simple approach is adopted to classify the risk as high, medium, or low, based on the level of the contribution rate. Table 3.1 below shows at which total contribution rate (referred to as the threshold) the contribution rate risk will be classified as high, medium or low. For example, if the contribution rate at any point exceeds 35 per cent, the contribution rate risk would be classified as high. As clarification, the contribution rate measured is the modified contribution rate (MCR) at the valuation date, as defined later in section 3.9. In determining the thresholds, the Sanlam Benchmark Survey (2015) provides insight into the current range of employer contributions in South African pension funds. In the 2015 survey (Sanlam, 2015), the average employer contribution rate is approximately 11 per cent per annum and the average employee contribution rate is 7.5 per cent.

**Table 3.1: Contribution rate risk thresholds**

<i>Risk classification</i>	<i>Contribution rate required (%)</i>
Low	<25
Medium	25-35
High	>35

One could argue that the above thresholds in Table 3.1 are conservative in that the low risk contribution rate is less than 25 per cent, while the average in the industry in 2015 was 11 per cent (Sanlam Benchmark Survey, 2015). This has the effect of biasing against a finding of significant risk from the use of best-estimate assumptions and the no-deficit clause. However, the premise is that a contribution rate of 25 per cent can be considered low risk provided it does not persist over multiple control periods. (This is discussed further in section 4.1.)

Solvency risk is defined as the ability of the fund to meet its liabilities as they fall due or should it be wound up (Haberman, 1997). Solvency risk is a key concern to members but also to the sponsor and trustees. As a measurement of this risk, the fund's Asset/Liability (A/L) ratio will be used. This provides an indication of the level at which

assets can cover the liabilities of the fund. Table 3.2 below will be used to determine the level of solvency risk in the fund. As for the contribution rate risk, the risk classification will be assigned if at any point, the Asset/Liability ratio of the fund breaches the threshold. For simplicity, it is assumed that the ongoing funding level acts as a proxy for the discontinuance funding level, showing what would be needed to secure future benefits on termination.

**Table 3.2: Solvency risk thresholds**

<i>Risk classification</i>	<i>A/L ratio (%)</i>
Low	>85
Medium	75-85
High	<75

These key risk measures aim to provide an overall view of the risk the fund faces. Ultimately, the risk classification will then provide an indication of the likelihood of members receiving their benefits, with consistent medium to high risk classifications suggesting unsustainable levels of risk.

### **3.4 Model points**

Model points were differentiated by a number of factors, such that each model point would represent a different type of individual. The factors used were gender, age, salary, time to retirement, and past service.

The member profile was calibrated to that of the average fund as per the Sanlam Benchmark Survey (Sanlam, 2015). This resulted in 2 000 model points of active members and 1 000 model points of pensioners, distributed across different age categories. For active members, ages ranged from 20 to 60 in increments of five years, resulting in savings periods ranging from 5 to 45 years based on a normal retirement age of 65. For pensioners, ages ranged from 50 to 85 years. Each model point was assumed to have an accumulated past service based on comparing their current age with an assumed work start age of 20 years. For example, a model point aged 40 is assumed to have 20 years of past service. A graph of the age distributions for both active members and pensioners can be found in Appendix A.

The contribution rate was assumed to be 7.5 per cent for all members, with the sponsor's contribution rate varying as per the funding requirements. This is consistent with contribution levels according to the Sanlam Benchmark Survey (Sanlam, 2015).

Critical to ensuring the credibility of the results is ensuring a stable membership profile in terms of age, gender, salary, and past service. Without this stability, two concerns

arise. First, it is a prerequisite to using a Projected Unit funding method, which is the method used in this research. Second, the instability would introduce additional variability into the contribution rate unattributed to actual experience (e.g., actual investment returns). This additional variability would have implications on the conclusions drawn. For example, in an ageing scheme, the best-estimate contribution rate would increase at each valuation, increasing the number of high risk classifications for the contribution rate. This would then confound the ability to answer the research question, as this increase in risk is not attributed to the constraints arising from PF117.

As discussed in section 2.4, Haberman (1997) addresses this concern by assuming a stationary population throughout the projection process and a similar approach is followed here. The inherent assumption is that any exits from (e.g., deaths or withdrawals) or entrants to the fund are neutral (does not generate any surplus or deficits) and the movements arise such that the exact same member distribution is maintained each year. While a simplifying assumption, it allows for the impact of PF117 to be more clearly assessed and hence better address the research question. However, while membership remains stable, stochastic variation is still assumed for investment returns, salary and pension increases (which constitute the most significant factors).

### **3.5 Valuation Basis**

The following basis was used to determine the expected fund value and required contribution rate.

Inflation and investment returns were modelled stochastically, which includes the three asset classes: equity, bond, and money market instruments. The approach to the stochastic modelling is described in detail in section 3.7 below. The assumptions for the mean and standard deviation for inflation and each of these asset classes are based on the historic real returns recorded by Firer and Staunton (2002), which captures 102 years of South African financial market history. The mean and standard deviation of these real returns can be found in Appendix B.

The use of the 102 years of South African market returns from Firer and Staunton (2002) presents a number of potential weaknesses: first, it ignores more relevant and recent market data; second, it incorporates periods characterised by materially different political, economic, and market conditions to those prevailing today; third, the composition of indices used and the availability and quality of data is likely to have varied over the period. However, the 102 years of South African market returns are used in the valuation basis for the following reasons: first, it is a complete dataset including a

significant history of asset class returns and associated correlations, ensuring consistency in the data presented; second, as the intention of this research is to conduct long-term simulations (26 years), reliance on returns over the recent past may not fully capture the behaviour of the various asset classes over the long term; third, it is a dataset that is published and readily available for use, and one of the few such datasets available for the South African context.

The pre-retirement investment portfolio is assumed to consist of an asset allocation of 60 per cent equity, 25 per cent bond and 15 per cent money market instruments. According to the Alexander Forbes Manager Watch Survey of Retirement Fund Investment Managers (2015:45), the average asset allocation of funds under the SA Best Investment View as at December 2015 was about 58 per cent Equity, 18 per cent Bond, and 18 per cent Cash (or Money Market). Together with the asset class returns shown in Appendix B, this resulted in a discount rate of about 10 per cent used in the deterministic valuation basis. Other asset classes such as offshore assets and property were not included for simplicity and to ensure a single consistent dataset for returns and correlations are used (i.e., Firer and Staunton, 2002). The introduction of these asset classes would likely reduce variability of the portfolio returns through increased diversification (i.e., through lower equity exposure).

One clarification on the inflation assumption needs to be highlighted. In South Africa, the Reserve Bank has adopted a monetary policy that aims to keep inflation within a target range (3-6 per cent per annum). For the stochastic projections of inflation and salary growth, no constraints have been placed on inflation, allowing more general conclusions to be drawn from the results. However, in the deterministic valuation basis, the long-term best-estimate assumption falls within the South African reserve bank's target range (about 6 per cent).

The post-retirement interest rate was assumed to be in line with that of a pure money market investment, after deduction of pension increases in line with CPI. This translated to an interest rate of about 1 per cent. Money market investments was selected over bonds as the post-retirement asset allocation due to the lower associated variability in returns. These two asset classes are however expected to behave similarly (given similar mean real returns and positive correlation, as shown in Appendix B). While it is assumed that pension increases are in line with CPI for simplicity, in practice, the Pension Funds Act allows pension increases to be restricted (below inflation) under certain conditions.

Depending on the size of the pensioner liability, allowing pension increases to be restricted below inflation could help reduce the effect of poor investment returns.

Salary inflation was assumed to be CPI plus 1 percentage point. This is substantiated by the valuation reports analysed by Davis and Kendal (2012); of the valuation reports that showed inflation and salary inflation assumptions (more than 400 valuation reports), about 286 used a best-estimate salary inflation 1 percentage point above the best-estimate inflation. In the deterministic valuation basis, this equated to about 7 per cent (based on CPI of about 6 per cent).

Pre- and post-retirement mortality was assumed to be in line with the PA(90) ultimate mortality table. Kendal and Franklin (1993), as cited by Strugnell, Dreyer, du Toit and van der Walt (2011), found that 12 valuers used the PA(90) ultimate mortality table for post-retirement mortality. Further, of the more than 400 valuation reports analysed by Davis and Kendal (2012), 96 funds used a best-estimate assumption of PA(90) for post-retirement mortality. A mortality improvement factor of 1 per cent per year was applied to capture improving mortality and longer life expectancy over time. At retirement, assumed to be age 65, pensions were assumed to be paid by the fund and not from a purchased annuity. For simplicity, the annuity was assumed to be a single life annuity with payments increasing in line with CPI.

### **3.6 Scope and other assumptions**

In modelling the fund value, a number of additional assumptions were made. These include:

1. A defined benefit (DB) fund was modelled as opposed to a defined contribution (DC) fund, due to PF117 largely impacting the former. Further, a pension fund as opposed to a provident fund was modelled, given the prevalence of the former amongst DB funds.
2. Tax and fund administration expenses were not included in the model as it has no material impact on answering the research question.
3. Contribution income and benefit outgo occur at the end of each month.
4. The initial value of the fund is equal to the total actuarial liability (i.e., 100 per cent funded). As this assumption may have considerable impact, sensitivity testing is carried out.
5. Fund valuations are calculated using deterministic assumptions.
6. The minimum total contribution rate is 7.5 per cent, which effectively represents the member's contribution rate.

### 3.7 Stochastic investment modelling

Given the purpose of the research and the level of detail required, a stochastic investment modelling approach similar to that outlined by Blake, Cairns and Dowd (2001) is adopted. The approach provides a simple and replicable method for developing the stochastic investment returns, for two reasons. First, the primary focus of this research is understanding the variability of investment returns on the security of members' benefits as opposed to the precise investment return. Second, the availability of readily developed models in the South African context, or that are easily replicable, are limited.

The fund's performance was determined under 10 000 stochastic simulations of investment returns. Inflation and the real investment returns for each of the asset classes (equity, bond, and money market) were modelled using a normal distribution with predefined mean and standard deviation (as shown in Appendix B).

The returns were first forecast independently to obtain uncorrelated returns over the entire period and stored in a matrix,  $R$ . A correlation matrix,  $C$ , between inflation and the asset class returns was then defined based on the historical correlations between real returns from Firer and Staunton (2002). The Cholesky decomposition of  $C$ ,  $D$ , was then calculated (i.e. a matrix  $D$  such that  $D^T D = C$ ). Multiplying the uncorrelated returns matrix  $R$  with the Cholesky decomposition  $D$  then produced the matrix of correlated returns,  $R^*$ . The Cholesky decomposition  $D$  can be found in Appendix B. The average real returns across the 10 000 simulations, compared to the valuation basis, are shown in Appendix C.

### 3.8 Fund assets

The fund assets are accumulated at a global level (i.e., not for each individual member) based on contributions from both the sponsor and member and the associated investment returns. Contributions to the fund are assumed to occur at the end of each month, which is consistent with salaries being paid in arrears. Each contribution is accumulated at the investment return to the end of the year, in order to determine the overall fund value at the end of each year.

Thus, the value of assets at the end of any year is determined as follows:

$$F_t = F_{t-1} * (1 + r) + (c_M + c_{E,t}) * s_t * FV - B_t \quad \text{Equation 3.1}$$

where:

$F_t$  represents the asset value at the end of year  $t$

$r$	represents the investment return for the investment portfolio
$c_M$	represents the contribution rate of the member (7.5 per cent)
$c_{E,t}$	represents the contribution rate of the sponsor in year $t$
$s_t$	represents the total salary roll in year $t$ , after escalation
$FV$	represents the future value of a payment of R1 per year, payable monthly in arrears, accumulated at the investment return $r$ per annum to the end of the year.
$B_t$	represents the benefit outgoing year $t$

### 3.9 Fund liabilities and contribution rate

The actuarial liability of the pension fund was calculated using the Projected Unit funding method, given its use in industry and support by literature (as discussed in section 2.5). Under this method, the actuarial liability is the discounted value of the benefits that have accrued over the past period of membership of the members, with allowance for future expected salary growth of the on-going benefits up to retirement age. The sponsor's Projected Unit Standard Contribution Rate (PUSCR) is then based on the present value of all benefits that will accrue after the valuation date for the selected control period, using projected final earnings, as a proportion of the present value of the members' earnings in the control period. The Projected Unit Modified Contribution rate (PUMCR), which is used for the analysis in this research, is then simply the PUSCR adjusted for any fund surplus or deficit.

The Projected Unit Actuarial Liability (PUAL) for active members was therefore calculated for each model point using equation 3.2 below:

$$L_t = n_t * s_t * A * \left( \frac{1+e}{1+d} \right)^{R-x} * \ddot{a}_{R,t} \quad \text{Equation 3.2}$$

where all variables are as defined in the previous equations, and:

$L_t$	represents the actuarial liability under the projected unit method in year $t$
$n_t$	represents the years of service at the valuation date $t$
$s_t$	represents the salary at the valuation date $t$
$A$	represents the accrual factor (assumed to be 2 per cent)
$e$	represents the salary growth (CPI plus 1 percentage point)
$d$	represents the discount rate used in the valuation basis
$R$	represents the normal retirement age (65)
$x$	represents the age of the member at the valuation date $t$



$\ddot{a}_{R,t}$  represents the value of a single life annuity, payable in advance from age  $R$  at time  $t$ , allowing for any pension increases and mortality improvements

For pensioners, the actuarial liability was calculated using equation 3.3 below:

$$L_t = p_t * \ddot{a}_{x,t} \quad \text{Equation 3.3}$$

where all variables are as defined in the previous equations, and:

$p_t$  represents the pension in year  $t$

$\ddot{a}_{x,t}$  represents the value of a single life annuity, payable monthly in advance from age  $x$  at time  $t$ , allowing for any pension increases and mortality improvements

The actuarial liability for the fund at any point in time would be the total of the actuarial liability for each model member. In calculating the actuarial liability, stable best-estimate assumptions were used. This means that while the asset values were determined using the stochastic inflation and investment returns, the actuarial liability was calculated using long-term averages to produce a stable result, as would be done in practice. For simplicity, the best-estimate basis has been kept constant during the projection period, as the assumption is that it is truly the long-term best-estimate basis. In practice, actuaries would base certain assumptions on the market at the valuation date (e.g., prevailing yield for bonds at the valuation date). An alternative approach therefore would be to revise the long-term averages based on the actual inflation and investment returns simulated. This approach would affect the PUMCR determined, reducing exposure to market fluctuations.

The Projected Unit Standard Contribution Rate is calculated every three years due to the required statutory valuation. As a result, the control period is also three years. The contribution rate is adjusted based on any actuarial surplus or deficit existing at the valuation date (i.e., a modified contribution rate). The PUMCR is therefore calculated according to the general equation 3.4 below:

$$C_t = \frac{P * A * s_t * \left(\frac{1+e}{1+d}\right)^{R-x} * \ddot{a}_{R,t}}{s_t * a_{p,t}} - \frac{F_t - L_t}{s_t * a_{Q,t}} \quad \text{Equation 3.4}$$

where all variables are as defined above, and:

$P$  represents the selected control period (3 years)

$a_{P,t}$  represents the present value of an annuity to determine the present value of earnings monthly in arrears over the control period  $P$  (allowing for salary increases)

$a_{Q,t}$  represents the present value of an annuity to determine the present value of earnings monthly in arrears over a period  $Q$  (allowing for salary increases), where  $Q$  can be equal to  $P$

The second term in the above equation adjusts the contribution rate for any surplus or deficit in the fund. Depending on the period selected, this term is adjusted to eliminate surpluses/deficits over that period. It is assumed here that  $P$  is equal to  $Q$ : as per the statutory requirement in South Africa, deficits need to be addressed over a three-year period. The control period therefore corresponds to this.

When faced with large contribution rate increases, funds may choose to review the contribution rate more frequently. For example, a fund may reassess the financial position on an annual basis as opposed to over a three-year period, particularly if poor market performance is followed by a strong recovery. For simplicity, the model in this research does not allow for this. The implication is that surpluses or deficits may be built up over the control period depending on market performance (e.g., period of continuing poor performance would result in an increasing deficit), resulting in either a large increase or decrease in the contribution rate at the start of the next control period.

It is important to note that the Projected Unit funding method is appropriate to use in the case of an open scheme; which is the scheme modelled in this research. The Projected Unit funding method requires a stable membership profile, which is not the case in a closed scheme due to a lack of new entrants and an ageing population. In the South African context, the number of open defined benefit pension funds has reduced in favour of defined contribution funds. The implication is that the model is not realistic for the current environment in South Africa, and therefore cannot be used to make general conclusions for South African pension funds as a whole.

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## 4 RESULTS

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This chapter presents the results across the 10 000 simulations run. Aggregated results (across all simulations) are first discussed, followed by individual results (for particular simulations). These simulations were run using the best-estimate valuation basis. Sensitivities were then conducted to test the variability of the results to key assumptions, including: investment returns, salary inflation, and the initial funding level. Thereafter, several strategies are investigated to mitigate the risk that may arise due to using best-estimate assumptions. These strategies include introducing margins on the investment return assumption and increasing the control period. Thereafter, the use of contingency reserves and the implications of the no-deficit clause are presented.

The overall purpose of these results is to understand the risk that PF117 poses to pension funds: considering members, sponsors, and other stakeholders. As laid out in Chapter 3, this determination will largely be based on considering contribution rate risk and solvency risk, measured by the PUMCR and A/L ratio respectively.

### 4.1 Aggregated results

The results shown below refer to the “Base” scenario, and will be referred to as this in the sections below. The Base scenario uses best-estimate assumptions (no margins included) which are then adjusted in later simulations. Table 4.1 below shows the results of the simulation against the criteria in Chapter 3. The results are shown for the two key risk measures: the maximum PUMCR and the minimum A/L Ratio.

The simulations show that under the PUMCR measurement, 68 per cent of the simulations resulted in a high risk classification (PUMCR > 35 per cent over the first 26 years). In terms of the A/L Ratio, 47 per cent of the simulations were classified as high risk (A/L < 75 per cent over the same period).

**Table 4.1: Risk classification of projected PUMCR and A/L ratio - Base scenario**

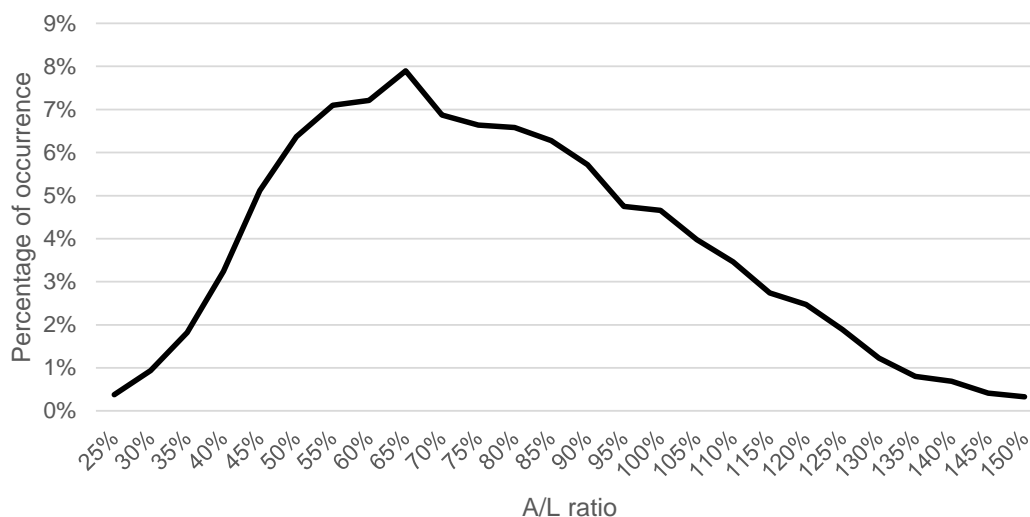
<i>Risk classification</i>	<i>PUMCR (%)</i>	<i>A/L ratio (%)</i>
Low	31	40
Medium	1	13
High	68	47

The results suggest the use of best-estimate assumptions without contingency reserves places the fund at risk – both in terms of contribution rate risk and solvency risk. The high occurrence of the high risk classification, for both PUMCR and the A/L ratio, is influenced by two factors. First, no level of conservatism has been adopted in the

valuation basis; neither in the assumptions nor as an explicit contingency reserve. This makes the PUMCR and A/L ratio particularly sensitive to adverse experience (e.g., poor investment returns). Second, the definition of the risk measures for both the PUMCR and A/L ratio naturally lends itself to a higher occurrence of high risk classifications. For example, for any particular simulation, if the PUMCR exceeds 35 per cent at any point in the first 26 years the simulation is classified as high risk. One could argue that alternative definitions of risk may also be appropriate (e.g., if the PUMCR exceeds 35 per cent for two successive valuation periods), which may lend itself to fewer high risk classifications. For example, under the base scenario, about 65 per cent of the high risk classifications had a PUMCR exceeding 35 per cent for two or more successive valuation periods.

Figure 4.1 below shows the distribution of the minimum A/L ratio across the 10 000 simulations. The median minimum A/L ratio is approximately 77 per cent, classified as medium risk. The occurrence of A/L ratios greater than 100 per cent is due to the assumed minimum contribution of 7.5 per cent – which represents the member’s contribution rate. In simulations where there were consistently strong investment returns, the minimum contribution rate led to surplus being built up in the fund.

**Figure 4.1: Distribution of minimum A/L ratio distribution – Base scenario**



The definition of risk applied here raises an important consideration when using best-estimate assumptions. Best-estimate assumptions would likely be developed with a medium to long-term time horizon in mind, and therefore may meet this definition over that term. There is therefore risk when looking at a shorter term: in any particular year, contribution rates required or A/L ratios may simply be unsustainable for the sponsor. The use of some conservatism, whether through margins or explicit contingency reserves,

may therefore be necessary to reduce this risk in the short term. The risk is that the no-deficit clause may prevent this, under the guidelines of PF117.

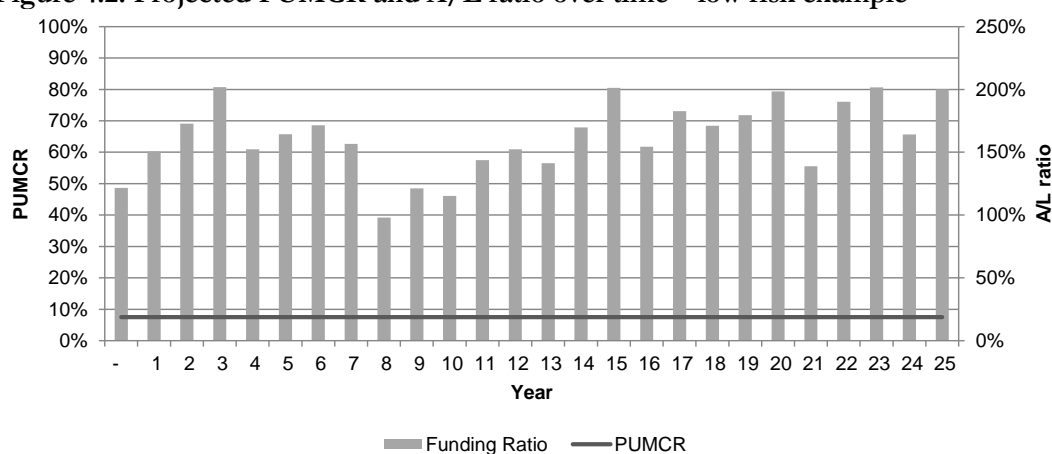
## 4.2 Individual results

To provide an overview of the types of output produced (and hence how the risks are determined), results are shown below for two particular simulations: an example of a low risk simulation and an example of a high risk simulation. Table 4.2 and Table 4.3 show the risk classification under both the PUMCR and A/L metrics. Figure 4.2 and Figure 4.4 show the fund's PUMCR and A/L ratio over the same period. Figure 4.3 and Figure 4.5 show the real investment returns for the same period for each of the three key asset classes (equity, bond, and money market). In the figures below, year 0 refers to the fund position at the end of the first year.

**Table 4.2: Risk classification of PUMCR and A/L ratio – low risk example**

<i>Risk metric</i>	<i>Measure (%)</i>	<i>Classification</i>
PUMCR	8	Low
A/L Ratio	98	Low

**Figure 4.2: Projected PUMCR and A/L ratio over time – low risk example**



**Figure 4.3: Projected real asset class returns over time – low risk example**

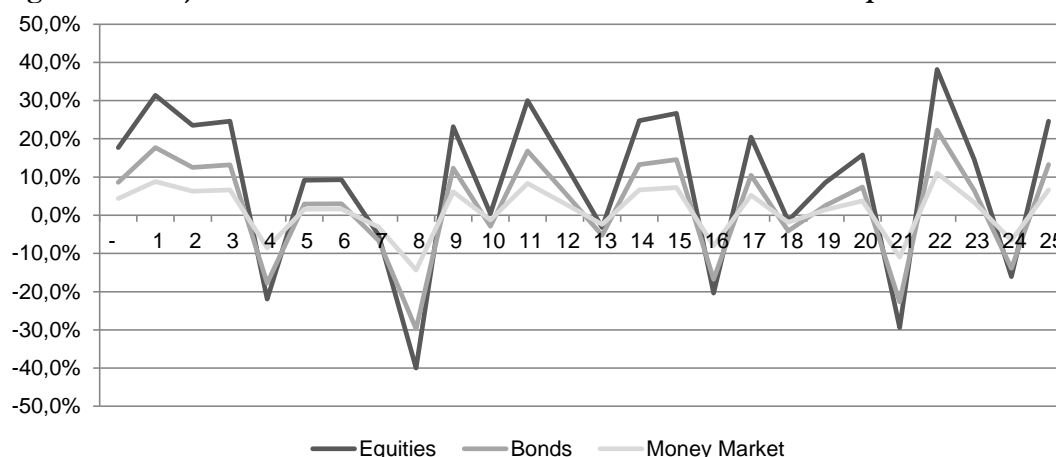
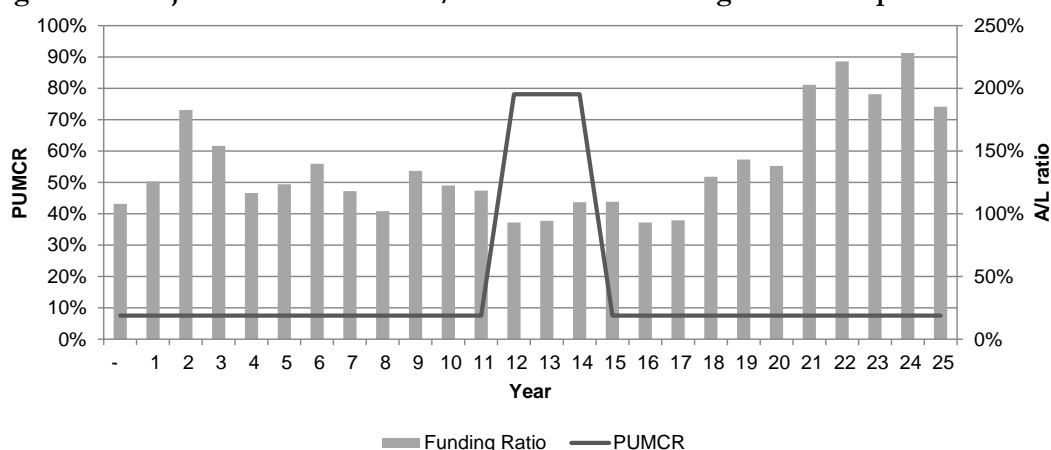


Table 4.2, Figure 4.2, and Figure 4.3 above show the typical fund performance resulting in a low risk classification. In this simulation, strong investment returns in early years allowed the fund to build up, resulting in high A/L ratios in early years (up to year three). The A/L ratio follows the investment returns, with weak investment returns in year four reducing the A/L ratio accordingly. The following strong investment returns again led to a strong A/L ratio building up after year four. Note that in this simulation, the A/L ratio grew in excess of 100 per cent due the minimum contribution rate of 7.5 per cent. This assumption results in excess funds being built up when investment returns are strong and a contribution rate lower than 7.5 per cent is required.

**Table 4.3: Risk classification of PUMCR and A/L ratio – high risk example**

<i>Risk metric</i>	<i>Measure (%)</i>	<i>Classification</i>
PUMCR	78	High
A/L Ratio	88	Low

**Figure 4.4: Projected PUMCR and A/L ratio over time – high risk example**



**Figure 4.5: Projected real asset class returns over time – high risk example**

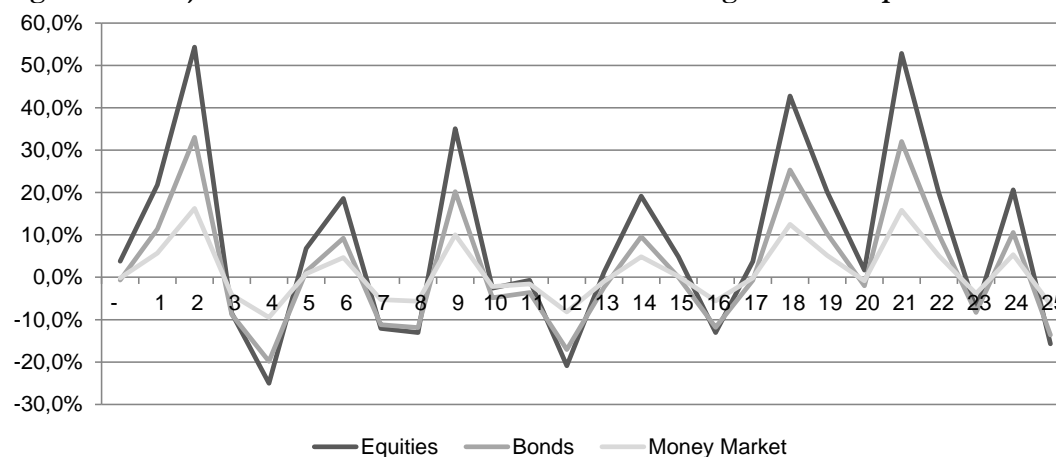


Table 4.3, Figure 4.4, and Figure 4.5 above show the same outputs for a high risk simulation. Here, poor investment performance in the early years (year 3 to year 4, year 7 to year 8, and year 11 to year 12) resulted in high contribution rates requirements in years 12 to 14. In particular, the poor investment returns in years 11 to 12 resulted in the A/L ratio falling below 100 per cent; contributing to the sharp increase in the PUMCR in years 12 to 14. The increase in PUMCR is also driven by a number of additional factors (e.g., growth in the salary roll, relative gearing of pensioner liabilities). The improved investment returns thereafter, allowed the PUMCR to reduce eventually to a more manageable level (7.5 per cent) for the remaining period.

### 4.3 Sensitivity of the results

To understand the sensitivity of this Base results, simulations are conducted again after changing key assumptions in the projection. These assumptions include the actual investment return, salary inflation, and initial funding level. For investment returns, the actual mean real return for each of the asset classes are increased by 1 percentage point. For salary inflation, a 1 percentage point increase is assumed (i.e., resulting in salary inflation effectively being CPI plus 2 percentage points). For the initial funding level, it is assumed that the fund starts 10 per cent underfunded (effectively a 90 per cent A/L ratio). Apart from the initial funding level sensitivity, all sensitivities start with a 100 per cent funding ratio. The results of the sensitivities are shown in Table 4.4 below.

**Table 4.4: Impact on risk classification of PUMCR and A/L ratio under sensitivities**

Risk classification	PUMCR (%)				A/L Ratio (%)			
	Base	Investment return	Salary Inflation	Funding level	Base	Investment return	Salary inflation	Funding level
Low	31	37	23	19	40	48	31	30
Medium	1	2	1	1	13	13	13	15
High	68	61	76	79	47	39	56	55

As can be seen from Table 4.4, these key assumptions can have a noticeable impact on the risk classification. The results presented are also what one would intuitively expect. For investment returns, the increase in actual mean real return has increased the number of low risk classifications under the PUMCR from 31 per cent in the Base to 37 per cent (and from 40 per cent to 48 per cent for the A/L ratio). Given the impact of investment returns on the results, a funding strategy using this assumption is developed as a potential method to mitigate risk (discussed in section 4.4 below). The results are also sensitive to the initial funding level assumed – as shown in Table 4.4.

#### **4.4 Funding strategies**

The Base scenario results, as well as the above sensitivities, indicate the use of best-estimate assumptions can lead to significant risk for the fund. Under the constraints of PF117, it therefore becomes increasingly important to understand ways to mitigate this risk. This section, as well as section 4.5, investigates these potential strategies, ranging from introducing conservatism into the basis to applying an overall contingency margin. It is important to note that in order to ensure that the results are comparable with the Base scenario, the same actual performance of the fund was used as in the 10 000 simulations of the Base scenario. In other words, in the Base scenario, 10 000 simulations of investments returns, inflation, and other assumptions were simulated for the forecast period. In the following analyses, the same forecasted investment returns, inflation and other assumptions are used. This ensures that the results are only impacted by the change in the funding strategy used and hence the true impact of the strategy is shown.

First, the impact of introducing conservatism into the valuation basis is investigated. Following the approach of Thornton and Wilson (1992), the focus is on the investment return assumptions given its relative importance and impact. Thornton and Wilson (1992) also argue that the investment return assumption is the element where it may be appropriate consciously to adopt a margin. Further, as shown by Davis and Kendal (2012), this seemed to be the approach adopted by the majority of funds post the introduction of PF117 where valuation bases were explicitly strengthened (as described in section 2.1). Second, the impact of changing the control period (from three years in the Base scenario, to five years) is investigated. The results of these simulations are shown in Table 4.5 and Figure 4.6 below.

##### **4.4.1 Investment returns**

The simulations were run again using more conservative investment return assumptions in the funding basis. Specifically, for each of the equity, bond, and money market asset



classes, the real investment return assumptions in the valuation basis are reduced by 1 percentage point. The overall effect resulted in the real portfolio return also decreasing by 1 percentage point. This strategy will be referred to below as the Investment Return strategy.

The results of the simulation show a marginal improvement in the A/L ratio, with the high risk classification reducing from 47 per cent in the Base scenario to 45 per cent in the Investment Return sensitivity. There was also a change in the low classification (from 40 per cent to 42 per cent), while the medium risk classification remained the same at 13 per cent. These results are shown in Table 4.5 below. The more conservative investment return assumptions in the funding basis, however, led to higher PUMCR maximums as well. The proportion of the PUMCR classified as high risk increased slightly from 68 per cent in the Base scenario to 69 per cent in the Investment Returns strategy. The lower investment return assumption effectively lowered the discount rate used to determine the PUAL under the funding basis, increasing the PUAL and the required contribution. The PUMCR under the Investment Return strategy has a higher maximum PUMCR compared to the Base scenario. The same, however, applies to the A/L ratio, with the Investment Return scenario showing a marginally higher minimum A/L ratio, as shown in Figure 4.6.

The analysis above is an important part of the research. In PF Notice No. 2, the FSB states that trustees should only allow funding on a minimum best-estimate basis if the trustees believe the sponsor has the means to cover future shortfalls that may result. This analysis therefore provides valuable help for trustees in understanding the nature of the additional risks that go with funding on a best-estimate basis compared to a more prudent basis.

An alternative approach to review the results of this simulation would be to measure the assets (funded using the more conservative investment return assumptions) against the best-estimate liabilities. This would likely show a larger impact on the A/L ratio than that suggested above, as liabilities are being measured at a higher level of security.

Overall, the effect of this as a funding strategy is an immediate and sustained increase in the PUSCR and PUAL. This is reflected in the PUMCR column of Table 4.5. Over time, the difference with the Base scenario will begin to release surplus which will show first as a reduction in risk of the A/L ratio in Table 4.5. The A/L ratio in Table 4.5 therefore actually overstates the risk relative to the Base scenario.

#### 4.4.2 Control period

A similar analysis was carried out for the control period. In the Base scenario, a control period of three years was used to determine the PUMCR. To test the sensitivity, a control period of five years was used. The rationale for a longer control period was to help reduce fluctuations in the PUMCR given short-term variability in investment returns and other assumptions. This strategy will be referred to as the Control Period strategy.

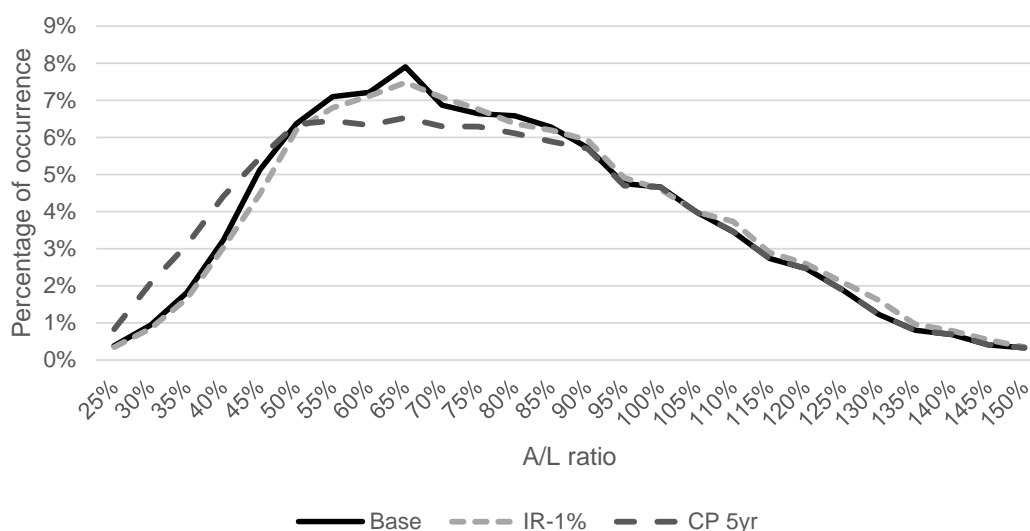
The results in Table 4.5 below show that the increased control period resulted in a reduction in the PUMCR risk classification. Compared to the Base scenario, the high risk classification for the PUMCR reduced from 68 per cent to 63 per cent. The A/L ratio risk classification also remained relatively unchanged, with a similar high risk classification (48 per cent).

More interestingly, however, while the risk classifications remained similar to the Base scenario, there was a significant reduction in the maximum PUMCR within the high risk classification. The distribution of the PUMCR has effectively shifted toward the left, resulting considerably lower maximum PUMCRs. Specifically, under the Control Period scenario the median maximum PUMCR was reduced by about 40 per cent. The result shows the increased control period, under best-estimate assumptions, helps to reduce the contribution rate risk. Increasing the control period leaves the liability unchanged whilst increasing the PUSCR. This creates a surplus which, over time, reduces the PUMCR. The contribution rate risk would therefore initially increase, but then decrease overall. The solvency risk should start decreasing immediately.

**Table 4.5: Impact on risk classification of PUMCR and A/L ratio of funding strategies**

<i>Risk classification</i>	<i>PUMCR (%)</i>			<i>A/L Ratio (%)</i>		
	<i>Base</i>	<i>Investment return</i>	<i>Control period</i>	<i>Base</i>	<i>Investment return</i>	<i>Control period</i>
Low	31	30	35	40	42	39
Medium	1	1	2	13	13	12
High	68	69	63	47	45	48

**Figure 4.6: Distribution of minimum A/L ratio under alternative funding strategies**

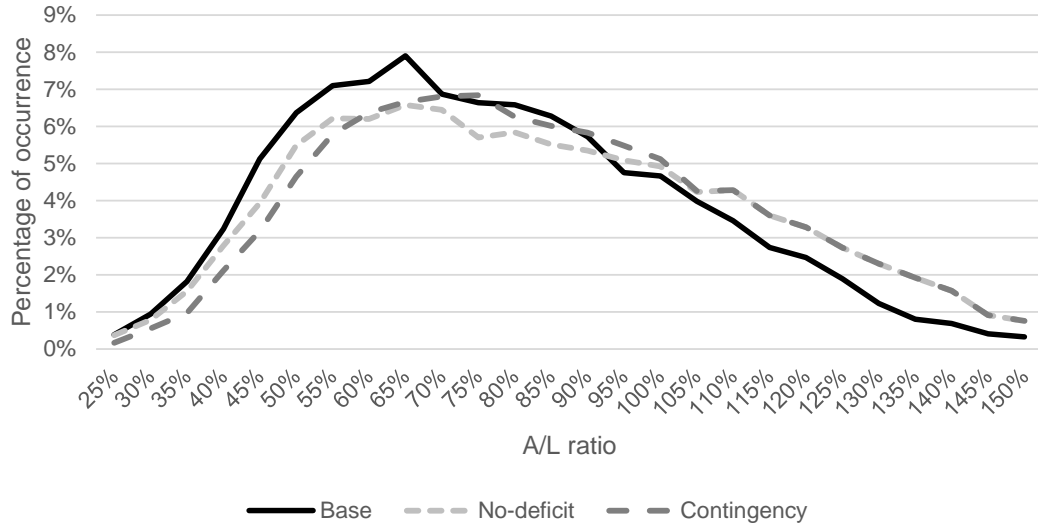


#### 4.5 Contingency reserves

The use of contingency reserves for prudence would allow for considerably greater transparency in the degree of prudence adopted; as is required by regulation 35. It also effectively represents a potential strategy for mitigating contribution rate and solvency risk. However, as discussed in Chapter 2, the peculiar nature of the no-deficit clause (where it prevents any contingency reserve from putting the fund into deficit) has a number of implications. To test these implications, the simulations were run under two additional scenarios. Under both scenarios, a 10 per cent contingency margin was added to the overall fund. The 10 per cent margin was selected to suitably illustrate the effect of the contingency margin, and to be in line with the findings of Thornton and Wilson (1992), which as discussed in section 2.2, found that the average basis may include margins that lead to an overestimation of benefits of approximately 10 per cent. In the first scenario, the no-deficit clause is ignored in the simulations, resulting in the contingency margin always being applied (referred to as the Contingency scenario). In the second scenario, the no-deficit clause is included, resulting in the contingency margin applied potentially being less than 10 per cent (and as low as 0 per cent in some cases) where the contingency reserve would put the fund into deficit. The contingency reserve is assumed to be funded through an increase in the contribution rate, starting from a position of being fully funded. The results of these scenarios, together with the base scenario, are shown in Table 4.6 and Figure 4.7 and are discussed below.

**Table 4.6: Impact on risk classification of PUMCR and A/L ratio of contingency reserve**

<i>Risk classification</i>	<i>Base</i>	<i>PUMCR (%)</i>		<i>Base</i>	<i>A/L Ratio (%)</i>		
		<i>Contingency</i>	<i>No-deficit</i>		<i>Contingency</i>	<i>No-deficit</i>	
Low	31	31	40	40	50	48	
Medium	1	1	1	13	13	12	
High	68	68	58	47	37	40	

**Figure 4.7: Distribution of minimum A/L ratio with contingency reserve**

#### 4.5.1 Contingency scenario

As mentioned above, the Contingency scenario assumes a 10 per cent contingency margin in the funding basis, ignoring the impact of the no-deficit clause. This implies the contingency margin is applied at each valuation date to the full 10 per cent margin. The results show a significant improvement in the A/L ratio. Table 4.6 above shows that the proportion of high risk classifications decreases from 47 per cent in the Base scenario to 37 per cent in the Contingency scenario. This is also demonstrated in the minimum A/L ratio distribution, as shown in Figure 4.7 above. As one would expect, the A/L ratio distribution under the Contingency scenario is shifted to the right (increase in the occurrence of higher A/L ratios compared to the Base scenario).

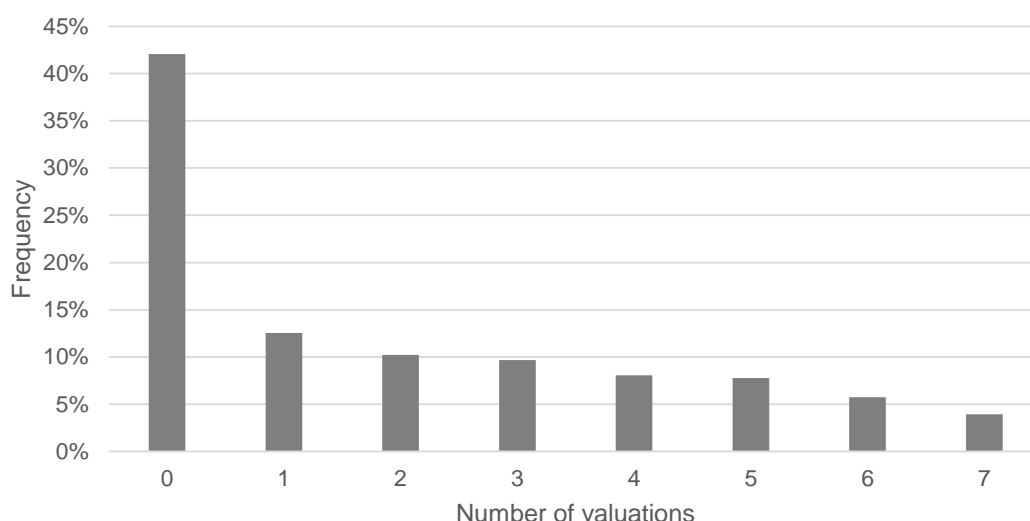
#### 4.5.2 No-deficit scenario

This scenario assumes the no-deficit clause applies along with the 10 per cent contingency margin. The no-deficit clause can effectively have three outcomes on the actual contingency margin applied. First, where a fund deficit does not occur, the full contingency margin of 10 per cent would be applied. Second, where the fund is already in deficit, a contingency margin of zero per cent would be applied. Third, where a contingency margin of 10 per cent would put the fund into deficit, but a contingency margin less than 10 per cent would not, this reduced contingency margin would apply.

The results in Table 4.6 above show that the contingency margin has a reduced effect on the A/L ratio risk classification compared to the Contingency scenario. Under the Base scenario, the A/L ratio had a high risk classification in 47 per cent of the simulations. While this proportion is reduced to 40 per cent under the No-deficit scenario, the Contingency scenario had a greater improvement (reducing the proportion of high risk simulations to 37 per cent). This is largely due to the no-deficit clause preventing the use of contingency margins when it would result in a fund deficit, and hence reducing additional contributions from the sponsor.

To investigate this in more detail, an analysis is conducted on the frequency of the no-deficit clause would be used and how often it prevented (or reduced) the contingency margin being applied. Figure 4.8 shows, across the 10 000 simulations, the number of valuations where the no-deficit clause prevented (or reduced) the contingency margin applied. This is examined over a period of seven valuations, which corresponds to the period used for the analysis above. The figure shows that in 42 per cent of the simulations, the no-deficit clause had no impact on the contingency margin applied. Therefore, in 58 per cent of the scenarios, the no-deficit clause prevented (or reduced) the contingency margin that could have been applied. In about 4 per cent of the simulations, the no-deficit clause reduced the contingency reserve that could be applied in all seven valuations.

**Figure 4.8: Frequency of the no-deficit clause – 100 per cent initial funding value**



#### 4.5.3 Implication of the results

The results of the contingency reserve scenarios suggest that the no-deficit clause can have implications on funds' ability to raise contingency reserves and hence on the solvency of the fund. Given the requirement to use best-estimate assumptions in the

funding basis, the need for explicit contingency reserves to protect the solvency of the fund becomes increasingly important. This was demonstrated by the impact of the Contingency scenario, which improved the A/L ratios and risk classification. However, the peculiar nature of the no-deficit clause indeed impedes the ability to raise contingency reserves, as shown under the No-Deficit scenario. The use of best-estimate assumptions therefore, in the absence of the ability to raise contingency reserves, increases both the contribution rate risk and solvency risk of pension funds.

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## 5 DISCUSSIONS AND CONCLUSIONS

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The overall purpose of this research was to understand the risk that PF117 poses to the security of members' benefits in defined benefit pension funds, particularly in the South African context. This chapter reflects on the extent to which the findings from the research address the research question highlighted in Chapter 1. This chapter starts with an overall synthesis of the findings from the research. The limitations of the research are then explained, portraying the context within which the findings should be interpreted. Thereafter, conclusions from the research are drawn, with possible extensions of the research also presented.

### 5.1 Findings

The results displayed in Chapter 4 suggest that the use of best-estimate assumptions in the funding basis can lead to significant risk for pension funds and the security of members' benefits, as measured by contribution rate risk and solvency risk. This has been demonstrated by the consistently large proportion of high risk classifications for the two key metrics: PUMCR and A/L ratio. Under the Base scenario, 68 per cent of simulations were classified as high risk under the PUMCR metric and 47 per cent under the A/L ratio, demonstrating significant risk for sponsors. The results also provided an important insight into best-estimate assumptions. Using best-estimate assumptions, while perhaps leading to a 50 per cent chance of underfunding in the medium to long-term, could lead to significant risk in the short-term if appropriate mitigating actions are not adopted (e.g., contingency margins). These short-term risks, such as fluctuating contribution rates, may lead to unsustainable requirements of the sponsor, and a risk to the security of members' benefits.

In the absence of explicit contingency reserves, alternative strategies for mitigating the potential risks of PF117 were investigated. One of these strategies was to introduce conservatism into the investment return assumption; a key driver of the overall fund performance. In line with the findings of Thornton and Wilson (1992), a small level of conservatism adopted in the assumption can reduce the fund's risk. As shown in the results above, a 1 percentage point margin on investment returns reduced the proportion of simulations that fell in the high risk category for the A/L ratio from 47 per cent to 45 per cent. It can also be argued that the investment return assumption is the appropriate area for introducing margins, given the importance of the assumption and the relative

ease with which it can be understood. Other mitigating actions investigated include increasing the control period (similar to moving towards an Attained Age funding method), which assists with smoothing out short-term fluctuations and limits variability in the PUMCR and A/L ratio.

Given the requirement to use best-estimate assumptions in the funding basis, the use of contingency reserves becomes increasingly important to help manage the fund's risk. The no-deficit clause from the PF117 circular, however, places difficult constraints on applying these contingency reserves, with significant impact on the fund's risk. As shown in the results in Chapter 4, in the absence of the no-deficit clause, a 10 per cent contingency margin could reduce the occurrence of high risk A/L ratios from 47 per cent to 37 per cent. With the no-deficit clause, however, the occurrence of the high risk classification is only reduced to 40 per cent. It was further shown that the no-deficit clause either prevented or reduced the contingency margin that could be applied in 58 per cent of the simulations.

## **5.2 Limitations of the research**

In order to isolate the impact of the constraints imposed by PF117, simplifying assumptions were made in modelling the pension fund. As was the approach followed by Haberman (1997), a stationary member profile is assumed in terms of age, gender, salary, and past service. As described in Chapter 3, this stability is a pre-requisite for adopting a Projected Unit funding approach, which would otherwise introduce additional variability to the PUMCR. A consequence of this, however, is that movements into and out of the fund are assumed to result in exactly the original member distribution. In practice, this is highly unlikely to be the case. The member distribution in pension funds would likely change from one valuation to the next. In the South African context, most defined benefit pension funds are not attracting new members, in contrast to the assumption above. Further, with these movements, surpluses and deficits would arise that would not necessarily be neutral/offset each other, impacting the funding ratio of the fund. The results therefore are not applicable to a fund with a changing membership profile, which is the majority of the remaining defined benefit pension funds in South Africa.

Further, the results from this research apply to an existing fund with predefined initial funding level. The results may differ based on the relative maturity of the scheme and size of the liabilities relative to salary roll, influencing the level of risk. For example, for a relatively young fund, a deficit could be handled by a smaller increase in the PUMCR than a mature fund. For a more mature fund, deficits may result in significantly larger



increases in the PUMCR, and hence a higher level of risk. The results of this research are therefore only applicable to an existing fund with an initial 100 per cent funding level.

This research adopts a simple approach to classify the PUMCR and A/L ratio as low, medium and high risk: representing contribution rate risk and solvency risk respectively. While this allows for a simple, intuitive understanding of the risks brought upon by PF117, the results become sensitive to the thresholds defined for low, medium and high risk. Changing the thresholds therefore will have an impact on the conclusions drawn. Furthermore, given that the PUMCR and A/L ratio are interrelated, they cannot be considered separately and in isolation.

One of the key assumptions influencing the results, as shown by the sensitivity analysis in section 4.2, is the assumed investment returns and the distribution thereof. For the stochastic investment modelling in this research, the approach outlined by Blake, Cairns and Dowd (2001) was followed, using a multivariate normal model to forecast correlated asset class returns using a Cholesky decomposition. A number of alternative stochastic investment models have been mentioned in this research (e.g., Maitland (2010) and Thomson (1996)) which may produce different results. The extent to which one can criticise the assumption that investment returns follow a multivariate normal distribution would lessen the validity of the results. More importantly however, the parameters of the distributions (mean and standard deviation) were based on data from Firer and Staunton (2002), which captures 102 years of South African financial market history. As discussed in section 3.5, excluding recent financial market experience (from 2002 to present) presents a significant limitation on the results; specifically, the investment return forecasts fail to capture recent changes in political, economic, and market conditions. The results are therefore only applicable a period similar to that leading up to 2002, and may not be relevant to the present context.

### **5.3 Conclusions**

Revisiting section 1.1, this research set out to answer the following question: Do the constraints of PF117 introduce additional risk to the security of members' pension benefits? The results above show that the use of best-estimate assumptions in the funding basis, coupled with the no-deficit clause, can pose significant risk to the fund, particularly in the short-term. While conclusions can be drawn for relatively mature funds, given this was the focus of the analysis, inferences can be made around the risk experienced by funds of other maturities (as discussed in section 5.2 above).

The no-deficit clause in particular impedes the ability to add the desired level of conservatism through contingency margins. As discussed in section 5.1 above, this occurred in more than half of the simulations conducted. This becomes an even larger concern for funds that are already in deficit: the no-deficit clause effectively prevents the fund from increasing contributions to improve the financial position of the fund.

To mitigate these risks, alternative ways of introducing conservatism into the funding basis are required, with possible options including incorporating margins into investment return assumptions or the removal of the no-deficit clause. Based on the evidence of Davis and Kendal (2012), it appears that many funds have in fact retained the margins in their valuation bases, if not strengthened them. This suggests that while PF117 aimed to increase transparency of the margins used by pension funds, the significant risk introduced by using best-estimate assumptions and the no-deficit clause simply caused many funds to continue using margins in their valuation bases.

#### **5.4 Possible extensions of the research**

The findings and conclusions of this research have prompted a number of avenues for further investigation. A natural extension of this research would be to investigate the performance of defined benefit pension funds since the introduction of PF117 (2004) to present. Building on the work of Davis and Kendal (2012), understanding the extent to which the use of best-estimate assumptions has been adopted by pension funds, and the implications it has had on the level of risk (e.g., PUMCR and A/L ratio) will provide insight into what has actually happened in practice.

From a modelling perspective, there is an opportunity to investigate the impact of stochastic decrements from the fund, including mortality, withdrawal and morbidity. These decrements could introduce additional strains (or surpluses) on the fund. Deterministic assumptions for mortality, withdrawal and morbidity would be required for the valuation basis, with the actual experience being determined stochastically. The best-estimate assumption for both withdrawal and morbidity could be informed by the paper by Davis and Kendal (2012). However, some additional thought would be required to define the associated stochastic distributions.

One could also investigate further different strategies for dealing with surplus and deficits within the context of PF117. This research investigates the impact of eliminating any deficits over three years (the statutory requirement) and the no-deficit clause. Further strategies could be tested for managing both deficits and surpluses. One could allocate the surplus to the members through alternative options (a simple increase in liability on a

DC basis which would remain neutral relative to future fund performance, or purchasing past service for the member which would be affected by future fund performance). Another strategy would be to allocate the surplus to the employer to ensure employer contributions rates are kept at manageable levels.

Beyond contribution rate risk and solvency risk, alternative measures of risk could also be investigated. Alternative risks that could be considered include the risk of breaching sponsor covenants or some measure of probability of default. For the risk of breaching sponsor covenants, an understanding of the typical sponsor covenants is first required. The model could then be extended firstly to measure these risks, and secondly, to allow for corrective action to take place before the covenant is breached.

## **5.5 Summary of the research**

In order to answer the research question outlined in section 1.1, this research began with a discussion of the relevant legislation and regulation guiding the valuation of pension funds in South Africa, particularly PF117 and the context for its introduction. A review of key literature was then presented, covering the use of best-estimate valuation bases, stochastic modelling techniques for investment returns, methods for forecasting pension fund risks, and funding methods for defined benefit pension funds. A stochastic model simulating pension fund assets and liabilities was then developed for the South African context, allowing for the risk assessment of PF117 under different funding strategies. A discussion of the results and avenues for further research was then presented.

This research developed a simple stochastic model for defined benefit pension funds tailored to the South African context. While this is sometimes done commercially for large pension funds, there are not many cases of this done in academic papers in South Africa. Using the stochastic model, the research provides a view on the additional risk to the pension fund should the trustees and sponsor elect to use a best-estimate basis for funding; as is the minimum acceptable under PF Notice No. 2. Further, this research also provides a view of the impact of various funding strategies on the risk the pension fund faces; which can assist trustees and sponsors in understanding the options they have for managing the pension fund.

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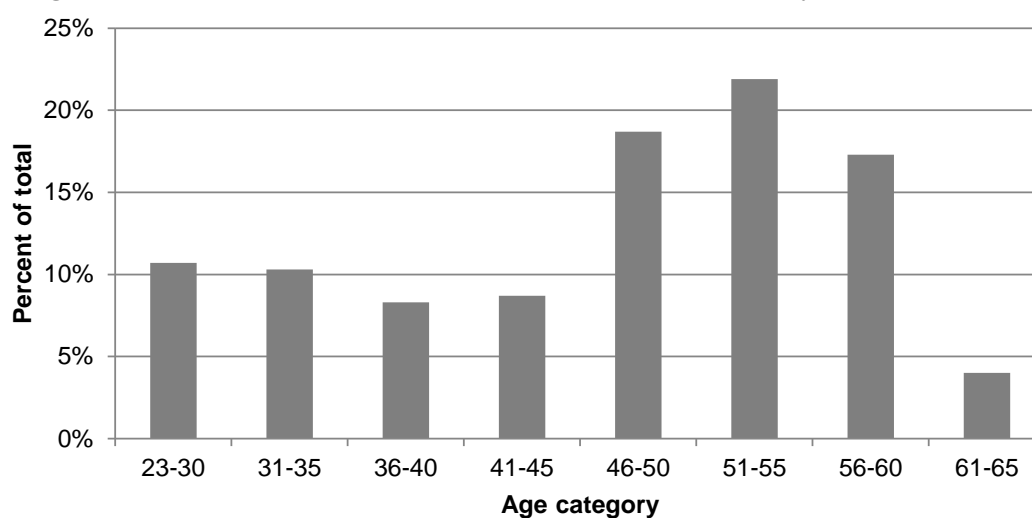
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## APPENDIX A

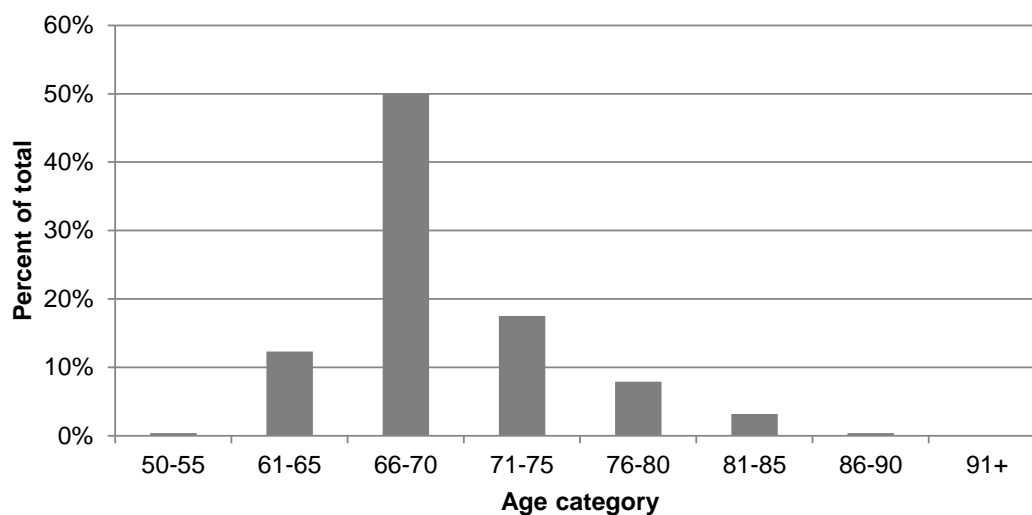
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**A.1: Age distribution of active members, Sanlam Benchmark Survey 2015**



**A.2: Age distribution of pensioners, Sanlam Benchmark Survey 2015**



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## APPENDIX B

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### B.1: Annual real asset class returns, Firer and Staunton (2002)

<i>Asset class</i>	<i>Mean (%)</i>	<i>Standard deviation (%)</i>
Inflation	4.8	7.7
Equity	7.0	22.6
Bond	1.5	10.6
Money Market	0.9	6.4

### B.2: Real return correlation matrix, Firer and Staunton (2002)

<i>Asset class</i>	<i>Inflation</i>	<i>Equity</i>	<i>Bond</i>	<i>Money Market</i>
Inflation	1	-0.25	-0.56	-0.69
Equity	-0.25	1	0.46	0.21
Bond	-0.56	0.46	1	0.66
Money Market	-0.69	0.21	0.66	1

### B.3: Cholesky Decomposition of real return correlations

<i>Asset class</i>	<i>Inflation</i>	<i>Equity</i>	<i>Bond</i>	<i>Money Market</i>
Inflation	1	-0.25	-0.56	-0.69
Equity	-	0.97	0.33	0.04
Bond	-	-	0.76	0.34
Money Market	-	-	-	0.64



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## APPENDIX C

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### C.1: Simulated asset class returns compared to valuation assumption

